Appendix 6 Water Quality Baseline and Models

A6. 1 Introduction

A6. 1. 1 Baseline Monitoring

By investigation and research of water quality baseline, the water quality baseline and its temporal and spatial distribution in the section of Stage Ⅲ Project could be grasped.

A6. 1. 2 Models of Hydraulics, Sediment and Water Quality

Models of hydraulics, sediment and water quality are used to simulate hydraulic traits, sediment transport and the law of pollutant transfer and conversion respectively before and after Stage Ⅲ Project, which could provide a scientific basis for EIA of Stage Ⅲ Project. The main contents of the models are as follows:

1) Hydraulic traits of the Shenzhen River, including river and tide traits before and after Stage Ⅲ Project operation;

2) Sediment transport as well as scouring and settling in the Shenzhen riverbed;

3) Pollutant transfer and conversion in the Shenzhen River, the water quality deformation before and after Stage Ⅲ Project as well as in the process of Stage Ⅲ Project,

A6. 2 Water Quality Baseline

The purpose of water quality baseline research is to identify the water quality and main pollutants, and realize the pollution extent, extension and variation with time and space in the section involved in Stage Ⅲ Project.

A6. 2. 1 Baseline Monitoring

According to the requirement of baseline evaluation, the baseline monitoring has been done. Section 6. 3 has described the sampling points, tested water quality parameters and applied measuring methods of baseline monitoring in details. The results are listed in Table A6. 1, A6. 2 and A6. 3, which are monitored during the flood season, normal season and dry season respectively.

Table A6.1

Baseline Monitoring Result during the Flood Season in 1998

Sample Point		Mouth of River Gange						San Pan River mouth						Ng Tung River mouth					
Sample Time		18August		19August		20August		18August		19August		20August		18August		19August		20August	
Tide Level		Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide
Temperature	(℃)	28.9	30.6	30.7	32.7	30.2	32.6	29.7	30.9	29.8	32.5	29.2	33	30.2	30.4	29.6	31.7	30.2	31.4
pH		7.46	7.78	7.68	7.72	7.65	7.7	7.59	7.73	7.53	7.62	7.53	7.79	7.54	7.58	7.59	7.61	7.44	7.49
SS	(mg/l)	1670	957	1220	80	136	98	76	129	71	154	44	200	26	253	34	59	10	9
Conductiviy	(μs/cm)	562	370	604	630	856	923	609	584	584	651	664	645	549	564	523	602	593	676
DO	(mg/l)	0.64	0.93	2.27	1.79	2.61	0.79	0.65	0.82	0.75	0.95	0.24	2.07	0.44	0.28	0.16	0.5	0.22	0.31
BOD_5	(mg/l)	51.7	45.1	21	23.4	25.4	10.4	22.4	33.4	25.4	22.8	17.4	21.4	15.2	16.9	31.8	31.6	21.5	23.0
COD_{Mn}	(mg/l)	51.9	23.6	21.2	12.0	20.0	12.4	12.4	18.1	12.3	27.3	12.26	14.37	9.89	22.5	14.3	13.1	14.1	10.5
COD_{Cr}	(mg/l)	607	127	89.9	41.2	78.7	63.7	41.2	89.9	37.5	112	52.5	86.2	18.7	97.4	48.7	48.7	56.2	45
NH_3-N	(mg/l)	11.1	5.69	13.2	13.4	15.9	17.5	13.8	11.8	14.0	14.4	15.6	18.0	9.63	11.2	11.9	14.5	15.8	17.6
NO_2-N	(mg/l)	0.012	0.176	0.081	0.111	0.123	0.052	0.055	0.117	0.083	0.02	0.01	0.112	0.012	0.015	0.025	0.016	0.041	0.033
NO_3-N	(mg/l)	0.032	0.17	0.017	0.012	0.012	0.023	0.01	0.016	0.004	0.003	0.026	0.082	0.047	0.015	0.005	<0.001	0.016	0.009
TN	(mg/l)	17.9	7.09	15.7	15.6	20.8	18.4	18.5	15.2	16.8	19.1	19.0	19.1	14.5	16.5	16.1	16.5	22.1	18.2
TP	(mg/l)	5.75	1.87	5.69	2.08	2.35	2.60	2.20	1.83	1.980	3.02	2.17	2.10	1.690	2.050	1.79	2.140	1.97	2.18
DP	(mg/l)	0.661	0.385	0.846	1.280	0.922	1.60	1.48	1.120	1.12	1.040	1.320	1.260	0.935	0.939	0.971	1.230	1.40	1.57
LAS	(mg/l)	0.716	0.598	0.211	0.598	0.266	0.675	0.321	0.558	0.231	0.807	0.506	0.497	0.312	0.777	0.98	0.784	1.11	0.659
Cr^{6+}	(mg/l)	0.003	0.003	0.002	0.002	0.007	0.005	0.003	0.002	0.002	<0.001	0.003	0.004	0.002	0.003	0.002	0.002	0.003	0.005
Phenols	(mg/l)	0.004	0.003	0.003	0.004	0.004	0.004	0.003	0.004	0.005	0.01	0.003	0.005	0.004	0.009	0.012	0.006	0.009	0.007
CN^-	(mg/l)	<0.001	0.003	0.002	0.003	0.003	<0.001	<0.001	0.003	0.003	<0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001	0.002	<0.001
Grease&oils	(mg/l)	3.58	4.9	0.72	1.3	1.77	1.75	0.91	1.69	0.97	4.74	1.28	1.36	0.99	3.76	2.53	1.77	2.44	1.57
Total fecal coliforms	(10^4cell/l)	57000	4500	4200	6200	5300	8000	9000	21000	7000	18000	8200	9000	8000	19000	15000	16000	21000	7000
Cl^-	(mg/l)	46.6	28.9	55.1	66.6	126	148	62.7	59.8	60.8	73.5	82.3	69.2	58.8	61.3	56.8	68.1	72.5	81.3
Tas	(mg/l)	0.026	0.029	0.015	0.009	0.006	0.008	0.005	0.009	0.006	0.007	0.005	0.009	0.006	0.01	0.006	0.006	0.005	0.005
THg	(mg/l)	0.00021	0.00026	0.00018	0.00019	0.00025	0.00014	0.00009	0.00016	0.00016	0.00028	0.00011	0.00024	0.00007	0.00033	0.00013	0.00018	0.00012	0.00009
Tcu	(mg/l)	0.0263	0.153	0.061	0.045	0.019	0.052	0.014	0.036	0.017	0.026	0.014	0.027	0.01	0.04	0.025	0.017	0.026	0.013
TZn	(mg/l)	0.604	0.658	0.231	0.121	0.172	0.11	0.09	0.152	0.099	0.218	0.042	0.148	0.106	0.24	0.43	0.102	0.379	0.08
TPb	(mg/l)	0.243	0.337	0.18	0.049	0.023	0.039	0.018	0.036	0.017	0.034	0.014	0.032	0.009	0.042	0.019	0.012	0.005	0.01
TCd	(mg/l)	0.002	0.002	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<001	<.0001	<.001	<.001	<.001
TNi	(mg/l)	0.028	0.003	0.02	0.009	0.007	0.01	0.007	0.011	0.007	0.009	0.004	0.012	0.01	0.012	0.023	0.006	0.016	0.005
TCr	(mg/l)	0.117	0.094	0.03	0.042	0.039	0.044	0.02	0.031	<.020	0.04	<.020	0.02	<.020	0.037	0.032	0.02	<.02	<.02

Table A6. 2 **Baseline Monitoring Result during the Normal Season in 1998**

Sample Point		Mouth of River Gange						San Pan River Mouth						Ng Tung River Mouth					
Sample Time		19October		20October		21October		19October		20October		21October		19October		20October		21October	
Tide Level		Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide
Temperature	(℃)	25.6	28.6	25.7	28.1	26.2	28.9	25.2	28.6	25.4	28.4	25.3	28.4	26.1	27.2	26.2	27	26	26.9
pH		7.21	7.21	7.28	7.28	7.21	7.31	7.25	7.49	7.31	7.49	7.19	7.51	7.22	7.24	7.28	7.3	7.2	7.19
SS	(mg/l)	12	36	5	7	5	35	14	18	70	22	44	8	7	7	57	6	56	31
Conductiviy	(μs/cm)	678	738	689	675	715	700	661	666	636	606	666	630	629	630	614	631	625	650
DO	(mg/l)	2.60	0.24	2.30	3.29	3.60	3.30	1.68	1.60	1.85	2.69	2.22	3.07	0.38	0.41	0.38	0.26	0.39	0.48
BOD_5	(mg/l)	11.3	21.2	14.9	16.3	8.27	18.80	16.3	19.6	18.20	15.8	12.7	20.7	26.0	19.80	23.3	21.2	18.1	23.5
COD_{Mn}	(mg/l)	8.48	66.3	11.3	12.7	10.9	13.4	15.9	28.5	9.87	4.93	16.5	25.5	12.4	12.0	13.40	15.2	10.3	11.1
COD_{Cr}	(mg/l)	79.0	502	50.6	60.0	66.4	79.0	79.0	284	72.7	72.7	142	161	69.5	49.0	66.4	80.6	60.0	60.0
NH_3-N	(mg/l)	10.7	12.7	11.9	9.24	7.09	8.23	14.3	14.9	14.1	12.2	14.1	11.7	14.7	12.5	13.4	13.7	14	12.4
NO_2-N	(mg/l)	0.314	0.539	0.192	0.404	0.264	0.251	0.652	0.347	0.545	0.287	0.009	0.273	0.024	1.099	0.018	0.821	0.007	1.115
NO_3-N	(mg/l)	2.37	1.55	2.47	2.72	2.98	2.88	1.17	0.108	1.33	1.93	<0.001	1.88	0.002	0.723	0.051	0.025	0.051	0.393
TN	(mg/l)	22.9	50.0	21.8	20.5	19.9	21.3	21.6	39.2	20.9	19.7	35.0	39.3	18.1	19.2	17.1	18.0	17.5	18.8
TP	(mg/l)	4.58	9.75	2.52	2.01	3.64	3.05	3.31	6.07	2.53	2.15	4.04	12.7	2.33	2.748	2.27	2.39	2.37	2.65
DP	(mg/l)	1.98	1.87	1.77	1.42	1.77	1.64	2.07	1.84	1.84	1.51	1.60	1.65	1.73	1.60	1.56	1.7	1.60	1.60
LAS	(mg/l)	0.512	0.64	0.499	0.428	0.519	0.53	0.552	0.68	0.62	0.742	0.574	0.684	0.965	0.635	1.09	0.783	0.982	0.673
Cr^{6+}	(mg/l)	0.002	0.002	0.003	0.004	0.003	0.004	0.003	0.002	0.003	0.003	0.002	0.003	0.003	0.003	0.002	0.003	0.002	0.003
Phenols	(mg/l)	0.015	0.025	0.039	0.099	0.029	0.034	0.02	0.024	0.027	0.013	0.025	0.019	0.045	0.024	0.056	0.022	0.053	0.027
CN^-	(mg/l)	<0.001	0.003	<0.001	0.002	<0.001	<0.001	0.005	0.004	<0.001	0.002	0.002	0.004	<0.001	<0.001	<0.001	0.004	0.002	0.002
Grease&oils	(mg/l)	0.73	4.21	0.91	0.91	1	0.91	1.52	1.84	1.20	0.77	0.87	0.92	2.22	1.29	2.22	1.42	1.85	1.22
Total fecal coliforms	(10^4cell/l)	9300	15000	8600	7500	5000	6400	8700	9300	7500	8000	6200	7500	9100	8400	989	6200	9500	4800
Cl^-	(mg/l)	82.5	95.2	78.8	85.6	95.2	87.9	72.3	79.1	67.9	66.9	80.5	70.8	72.6	73	70.8	68.9	73.7	76.9
Tas	(mg/l)	0.005	0.011	0.004	0.004	0.004	0.003	0.007	0.006	0.003	0.003	0.005	0.005	0.003	0.001	0.003	0.001	0.003	0.004
THg	(mg/l)	0.00003	0.00048	0.00006	0.00005	0.00007	0.00008	0.00004	0.00016	0.00004	0.00004	0.00007	0.00017	0.00013	0.00008	0.00005	0.00006	0.00004	0.00008
Tcu	(mg/l)	0.029	0.097	0.014	0.017	0.035	0.015	0.021	0.047	0.016	0.014	0.023	0.039	0.015	0.023	0.014	0.018	0.015	0.012
TZn	(mg/l)	0.064	0.613	0.073	0.104	0.066	0.085	0.105	0.244	0.089	0.072	0.113	0.282	0.140	0.099	0.118	0.123	0.110	0.064
TPb	(mg/l)	0.006	0.028	0.007	0.010	0.005	0.010	0.014	0.020	0.006	0.011	0.015	0.030	0.007	0.015	0.005	0.012	0.008	0.014
TCd	(mg/l)	<.001	0.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
TNi	(mg/l)	0.006	0.036	0.018	0.009	0.009	0.011	0.009	0.012	0.007	0.007	0.005	0.013	0.009	0.007	<.004	0.007	0.009	0.004
TCr	(mg/l)	0.047	0.103	<.020	<.020	0.049	<.02	<.020	0.027	<.002	<.002	<.02	<.02	0.02	0.021	<.02	<.02	<.02	<.02

Table A6. 3

Baseline Monitoring Result during the Dry Season in 1998

Sample Point		Mouth River Gange						San Pan River Mouth						Ng Tung River Mouth					
Sample Time		21December		22December		23December		21December		22December		23December		21December		22December		23December	
Tide Level		Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide	Spring Tide	Ebb Tide
Temperature	(℃)	22.6	20.8	22.8	21.3	22.3	20	23.4	20.9	24.2	21.2	23.4	20.4	22	20.5	23.1	20.4	21.7	19.4
pH		7.25	7.28	7.12	7.19	7.29	7.29	7.29	7.29	7.25	7.28	7.29	7.25	7.32	7.32	7.19	7.28	7.22	7.45
SS	(mg/l)	18	17	18	15	22	15	10	10	14	16	18	16	8	18	12	25	8	32
Conductivity	(μs/cm)	743	769	760	787	626	697	758	740	744	752	835	714	628	688	657	676	663	641
DO	(mg/l)	1.8	1.58	3.2	3.8	0.43	1.24	1.8	2.01	0.48	0.48	1.48	2.24	0.2	0.25	0.65	0.58	0.3	0.29
BOD_5	(mg/l)	13.2	16.0	16.8	21.0	25.8	22.8	21.5	21.7	25.5	29.1	26.4	33.8	26.0	24.8	35.3	18.8	28.4	26.2
COD_{Mn}	(mg/l)	11.6	12.2	10.0	9.63	21.1	12.3	9.94	13.4	12.5	13.9	22.1	12.0	12.8	21.9	12.0	15.3	15.2	12.5
COD_{Cr}	(mg/l)	105	38.1	64.8	37.6	104	55.1	55.1	41.3	55.1	64.8	98.5	64.8	33.6	168	42.1	379	44.1	243
NH_3-N	(mg/l)	9.07	12.7	8.5	8.72	17.03	14.9	14.09	16.3	12.8	14.4	20.3	15.4	14.5	13.3	12.6	12.0	12.5	13.3
NO_2-N	(mg/l)	0.207	0.213	0.206	0.211	0.17	0.15	0.45	0.807	0.417	0.654	0.014	0.656	0.017	0.236	0.01	0.326	0.017	0.021
NO_3-N	(mg/l)	5.60	4.55	6.26	6.33	0.759	3.06	4.30	3.35	3.90	3.01	0.049	2.96	0.030	0.683	0.015	0.891	0.453	0.009
TN	(mg/l)	20.7	22.6	21.1	19.6	25.3	23.1	21.6	23.2	22.8	20.0	28.8	22.7	17.8	21.1	18.5	19.9	18.1	20
TP	(mg/l)	2.60	2.88	3.37	2.96	5.67	4.02	3.31	2.63	2.47	3.26	4.63	3.62	2.73	4.79	2.94	3.62	2.75	3.63
DP	(mg/l)	1.86	2.13	2.59	2.24	4.15	3.33	2.45	2.87	2.22	2.68	3.24	3.00	1.86	1.70	2.15	1.94	1.77	2.24
LAS	(mg/l)	0.822	1.03	0.753	0.718	0.938	0.993	0.896	1.04	1.21	1.52	1.37	1.59	1.27	1.27	1.52	1.40	1.48	1.66
Cr^{6+}	(mg/l)	0.003	0.003	0.003	0.003	0.003	0.002	0.003	0.003	0.002	0.003	0.003	0.003	0.002	0.003	0.003	0.003	0.003	0.003
Phenols	(mg/l)	0.007	0.006	0.015	0.009	0.011	0.007	0.009	0.009	0.015	0.007	0.018	0.009	0.013	0.006	0.014	0.009	0.017	0.007
CN^-	(mg/l)	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.002	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Grease&oils	(mg/l)	0.48	0.53	0.45	0.39	1.09	1.00	0.61	0.71	0.78	0.98	1.22	0.76	0.96	0.81	1.07	0.69	1.33	0.81
Total fecal coliforms	(10^4cell/l)	1100	3400	300	2000	2700	3000	2400	3800	2800	3200	5400	3300	3900	2000	3400	2200	4000	5500
Cl^-	(mg/l)	101	105	103	113	50.5	76.7	95.3	92.1	94.8	92.6	101	79.2	76.0	94.0	81.7	85.1	81.7	76.7
Tas	(mg/l)	0.00	0.0025	0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0014	0.00	0.00	0.01	0.00	0.01
THg	(mg/l)	0.00007	0.00042	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00017	0.00	0.00004	0.00	0.00	0.00	0.00	0.00
Tcu	(mg/l)	0.037	0.02	0.06	0.03	0	0.06	0.02	0.02	0.03	0.02	0.03	0.02	0.017	0.04	0.02	0.07	0.02	0.05
TZn	(mg/l)	0.163	0.109	0.17	0.13	0	0.16	0.09	0.10	0.13	0.10	0.167	0.13	0.11	0.29	0.13	0.04	0.12	0.37
TPb	(mg/l)	0.017	0.011	0.02	0.02	0	0.02	0.03	0.01	0.01	0.01	0.017	0.01	0.007	0.07	0.01	0.05	0.01	0.04
TCd	(mg/l)	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
TNi	(mg/l)	0.011	0.009	0.012	0.009	0.011	0.01	0.01	0.009	0.01	0.008	0.009	0.007	0.018	0.014	0.017	0.023	0.01	0.022
TCr	(mg/l)	<.02	<.02	0.051	<.02	0.016	0.042	<.02	<.02	0.025	<.02	<.020	<.02	<.02	0.025	<.020	0.055	<.02	0.074

A6.2.2 Elutriation Experiment

To study the potential effect of dredging on the water quality of the Shenzhen River and realize the pollutants resuspended by construction disturbance, the elutriation experiment is done for the polluted bed mud or soil sampled from the section involved in Stage Ⅲ Project. In the light of the *National Standards for Toxicity Experiment Method of Waste Solid Elutriation of Non-ferrous Metal Industry* (*GB*5086-85), the solid sample is weighed, and then mixed with some freshwater in a series of ratios and immersed in settled time sequence. The analyzed pollutant content in the water is shown in the following Table A6.4.

Table A6.4 Result of Elutriation Experiment of the Polluted Mud or Soil (Unit: mg/L, Not Including pH)

Immersion Time (hr)	pH	SS	TN	TP	Cu	Pb	Cd	Cr	Hg	Ratio between Solid and Water
0	7.0	73800	20.2	0.107	<0.005	<0.005	<0.001	<0.01	<0.0001	
4	7.3	2112	17.5	0.108	<0.005	<0.005	<0.001	<0.01	<0.0001	
8	7.3	1925	19.6	0.102	<0.005	<0.005	<0.001	<0.01	<0.0001	
16	7.4	1024	20.4	0.104	<0.005	<0.005	<0.001	<0.01	<0.0001	
24	7.5	918	21.6	0.107	<0.005	<0.005	<0.001	<0.01	<0.0001	1 : 5.0
48	7.7	834	21.1	0.109	<0.005	<0.005	<0.001	<0.01	<0.0001	
72	7.7	165	25.7	0.114	<0.005	<0.005	<0.001	<0.01	<0.0001	
120	8.0	112	25.0	0.116	<0.005	<0.005	<0.001	<0.01	<0.0001	
240	7.4	139	28.6	0.172	<0.005	<0.005	<0.001	<0.01	<0.0001	
0	6.7	8880	12.6	0.052	<0.005	<0.005	<0.001	<0.01	<0.0001	
4	7.3	1795	14.3	0.056	<0.005	<0.005	<0.001	<0.01	<0.0001	
8	7.3	915	14.7	0.058	<0.005	<0.005	<0.001	<0.01	<0.0001	
16	7.3	492	14.5	0.057	<0.005	<0.005	<0.001	<0.01	<0.0001	
24	7.3	427	15.9	0.066	<0.005	<0.005	<0.001	<0.01	<0.0001	1 : 10
48	7.2	159	18.4	0.108	<0.005	<0.005	<0.001	<0.01	<0.0001	
72	7.8	185	19.4	0.106	<0.005	<0.005	<0.001	<0.01	<0.0001	
120	7.7	102	17.8	0.106	<0.005	<0.005	<0.001	<0.01	<0.0001	
240	7.6	116	19.9	0.108	<0.005	<0.005	<0.001	<0.01	<0.0001	
0	6.9	518	9.3	0.060	<0.005	<0.005	<0.001	<0.01	<0.0001	
4	7.4	351	8.77	0.048	<0.005	<0.005	<0.001	<0.01	<0.0001	
8	7.3	190	8.98	0.040	<0.005	<0.005	<0.001	<0.01	<0.0001	
16	7.1	138	9.99	0.046	<0.005	<0.005	<0.001	<0.01	<0.0001	
24	7.4	161	9.17	0.050	<0.005	<0.005	<0.001	<0.01	<0.0001	1 : 20
48	7.3	136	12.0	0.046	<0.005	<0.005	<0.001	<0.01	<0.0001	
72	7.3	118	11.6	0.050	<0.005	<0.005	<0.001	<0.01	<0.0001	
120	7.1	77	11.4	0.054	<0.005	<0.005	<0.001	<0.01	<0.0001	
240	7.3	73	12.7	0.066	<0.005	<0.005	<0.001	<0.01	<0.0001	

A6. 3 One-dimensional Hydraulic Model for the Shenzhen River

A6. 3. 1 *Model Selection*

To study the effect of Stage Ⅲ Project on the hydraulic characteristics of the Shenzhen River, one-dimensional non-steady flow mathematical model for open channel can be used to integrallty describe the characteristics of the mixing current by run off and tide in the tidal river.

A6. 3. 2 *Model*

(1) Essential equation

The one-dimensional hydraulic model for the Shenzhen River applies St. Venant equations of gradually varied unsteady flow. The flow $Q(x,t)$ and the water level $Z(x,t)$ are unknown variables.

The current continuous equation:

$$\frac{\partial Z}{\partial t} + \frac{1}{B}\frac{\partial Q}{\partial x} = 0; \qquad (A6-1)$$

The current equation of motion:

$$\frac{\partial Q}{\partial t} + \frac{\partial}{\partial x}\left(\frac{Q^2}{A}\right) + gA\frac{\partial Z}{\partial x} + gA\frac{Q|Q|}{K^2} = 0; \qquad (A6-2)$$

Where,

Z —— Water level (m)

Q —— Flow (m^3/s)

K —— Flow module

A —— Cross-section area for water passage (m^2)

B —— Water surface width (m)

g —— Gravitational acceleration

x,t —— Variables as time(s) and space(m) respectively

(2) Calculation scheme

The discrete current continuous equation and the water motion equation in the form of the following implicit scheme (see Figure A6.1) are used.

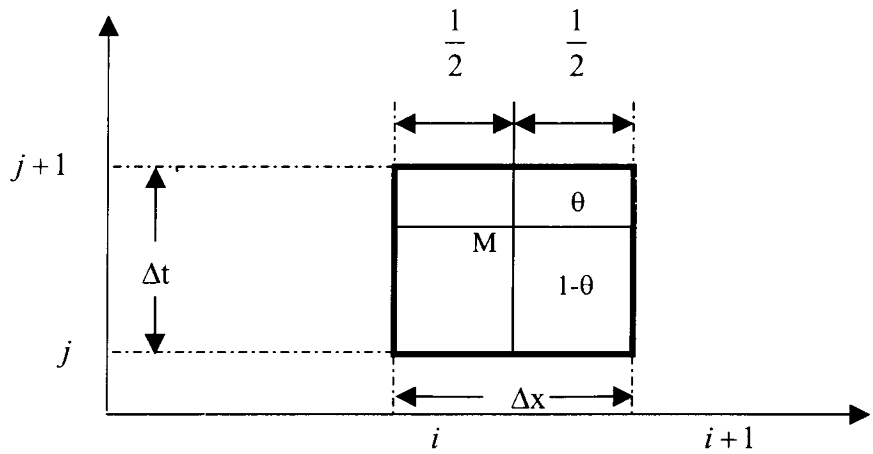

Figure A6.1 Preissmann Difference Scheme

$$\begin{cases} f \approx \frac{\theta}{2}(\triangle f_{i+1} + \triangle f_i) + \frac{1}{2}(f_{i+1}^j + f_i^j) \\ \frac{\partial f}{\partial t} \approx \frac{1}{2\triangle t}(\triangle f_{i+1} + \triangle f_i) \\ \frac{\partial f}{\partial x} \approx \frac{\theta}{\triangle x_i}(\triangle f_{i+1} + \triangle f_i) + \frac{1}{\triangle x_i}(f_{i+1}^j + f_i^j) \end{cases} \quad (A6-3)$$

Tailor series with first order approximation is applied in formula A6—3. the superscript j and the subscript i, which indicate time coordinate (t) and space coordinate (x), are substituted into the formula A6—1 and A6—2. Under the consideration of the river width B, cross-section area A and the flow modulus K as the monotone continuous function of water level Z, a linear equations are got as follows:

$$A_{1i}\triangle Z_{i+1}^j + B_{1i}\triangle Q_{i+1}^j + C_{1i}\triangle Z_i^j + D_{1i}\triangle Q_i^j = G_{1i} \quad (A6-4)$$

$$A_{2i}\triangle Z_{i+1}^j + B_{2i}\triangle Q_{i+1}^j + C_{2i}\triangle Z_i^j + D_{2i}\triangle Q_i^j = G_{2i} \quad (A6-5)$$

Where:

$$A_{1i} = 1 - \frac{4\theta\triangle t(Q_{i+1}^j - Q_i^j)}{\triangle x(B_{i+1}^j + B_i^j)^2}\frac{dB_{i+1}^j}{dZ_{i+1}^j}$$

$$B_{1i} = \frac{4\theta\triangle t}{\triangle x(B_{i+1}^j + B_i^j)}$$

$$C_{1i} = 1 - \frac{4\theta\triangle t(Q_{i+1}^j - Q_i^j)}{\triangle x(B_{i+1}^j + B_i^j)^2}\frac{dB_i^j}{dZ_i^j}$$

$$D_{1i} = -\frac{4\theta\triangle t}{\triangle x(B_{i+1}^j + B_i^j)}$$

$$G_{1i} = \frac{4\triangle t(Q_{i+1}^j - Q_i^j)}{\triangle x(B_{i+1}^j + B_i^j)}$$

$$A_{2i} = \frac{\theta\triangle t}{\triangle x}\left[-\frac{2(Q_{i+1}^j)^2 B_{i+1}^j}{(A_{i+1}^j)^2} + g(A_{i+1}^j + A_i^j) + g(Z_{i+1}^j - Z_i^j)B_{i+1}^j\right] + g\theta\triangle t\frac{Q_{i+1}^j|Q_{i+1}^j|}{(K_{i+1}^j)^2}\left\{B_{i+1}^j - \frac{2A_{i+1}^j}{(K_{i+1}^j)}\frac{dK_{i+1}^j}{dZ_{i+1}^j}\right\}$$

$$B_{2i} = 1 + \frac{4\theta\triangle t}{\triangle x}\frac{Q_{i+1}^j}{A_{i+1}^j} + 2g\theta\triangle t\frac{A_{i+1}^j|Q_{i+1}^j|}{(K_{i+1}^j)^2}$$

$$C_{2i} = \frac{\theta\triangle t}{\triangle x}\left[\frac{2(Q_i^j)^2 B_i^j}{(A_i^j)^2} - g(A_{i+1}^j + A_i^j) + g(Z_{i+1}^j - Z_i^j)B_i^j\right] + g\theta\triangle t\frac{Q_i^j|Q_i^j|}{(K_i^j)^2}\left\{B_i^j - \frac{2A_i^j}{(K_i^j)}\frac{dK_i^j}{dZ_i^j}\right\}$$

$$D_{2i} = 1 - \frac{4\theta\triangle t}{\triangle x}\frac{Q_i^j}{A_i^j} + 2g\theta\triangle t\frac{A_i^j|Q_i^j|}{(K_i^j)^2}$$

$$G_{2i} = \frac{\triangle t}{\triangle x}\left\{-2\left[\frac{(Q_{i+1}^j)^2}{A_{i+1}^j} - \frac{(Q_i^j)^2}{A_i^j}\right] + g(A_{i+1}^j + A_i^j)(Z_{i+1}^j - Z_i^j)\right\} - g\theta\triangle t\left\{\frac{A_{i+1}^j Q_{i+1}^j|Q_{i+1}^j|}{(K_{i+1}^j)^2} - \frac{A_i^j Q_i^j|Q_i^j|}{(K_i^j)^2}\right\}$$

The A6—4 and A6—5 equations can be resolved with the chase-method. Assume $\triangle Q$ and $\triangle Z$ meet the following linear relationship:

$$\triangle Q_i = E_i\triangle Z_i + F_i \qquad (A6-6)$$

Considering the randomicity of i, the following equation must also be correct.

$$\triangle Q_{i+1} = E_{i+1}\triangle Z_{i+1} + F_{i+1} \qquad (A6-7)$$

Substitute formula A6—6 into formula A6—4 and formula A6—5, respectively, and let:

$$\alpha = C_{1i} + D_{1i}E_i$$

$$\beta = C_{2i} + D_{2i}E_i$$

Then:

$$\triangle Z_i^{j+1} = L_i \triangle Z_{i+1}^{j+1} + M_i \triangle Q_{i+1}^{j+1} + N_i \qquad (A6-8)$$

Where:

$$L_i = \frac{-A_{1i}}{\alpha}$$

$$M_i = \frac{-B_{1i}}{\alpha}$$

$$N_i = \frac{G_i - D_{1i}F_i}{\alpha}$$

Substitute formula A6—6 into formula A6—4 and formula A6—5, respectively, and then work out $\triangle B_{i+1}^j$ with the formula A6—4 multiplying β and formula A6—5 multiplying α With association of formula A6—6, the following formulas can be got.

$$E_{i+1} = -\frac{\beta A_{1i} - \alpha A_{2i}}{\beta B_{1i} - \alpha B_{2i}}$$

$$F_{i+1} = \frac{\beta(G_{1i} - D_{1i}F_i) - \alpha(G_{2i} - D_{2i}F_i)}{\beta B_{1i} - \alpha B_{2i}}$$

Thus, formula A6—6 and formula A6—8 form a recursion relationship. The solution can be got with the chase-method if the initial condition and boundary condition are substituted into them.

A6. 3. 3 *Designed Flow and Designed Tide Level*

In the hydraulic model, the hydrographs of the designed flow and tide level at the Shenzhen River estuary for withstanding 50-year recurrence and 10-year recurrence flood are extracted from *Preliminary Design Report of Phase Two in Stage* Ⅲ of the Shenzhen River Regulation Project. *See Figure* A6. 2—A6. 4.

A6. 4 One-dimensional Sediment Model for the Shenzhen River

A6. 4. 1 *Model Selection*

To study the variation of sediment transport, scouring and siltation in the Shenzhen River affected by Stage Ⅲ Project, the solution is worked out by non-coupling method with the current equation and sediment transport and channel deformation

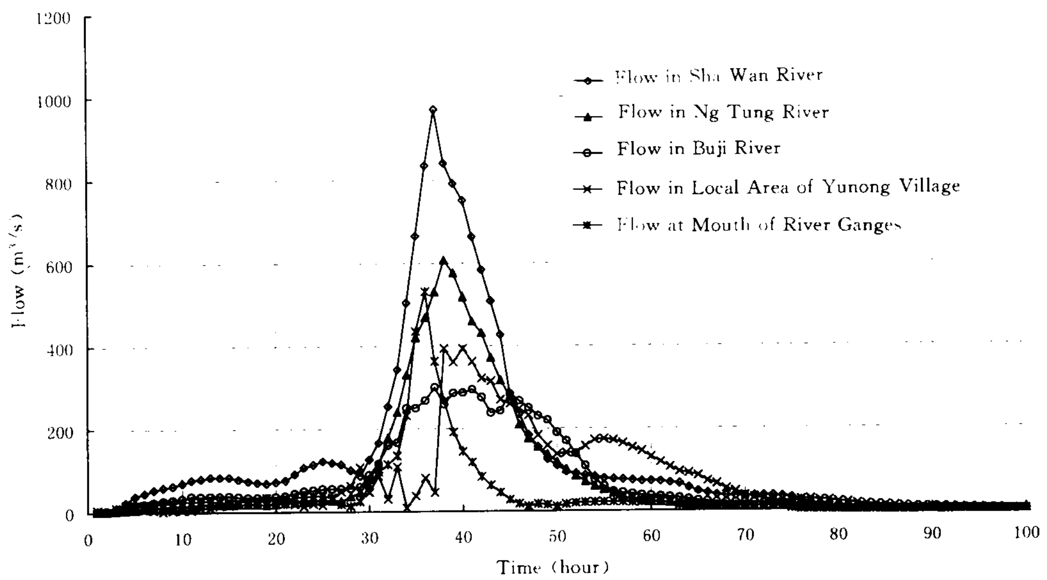

Figure A6. 2 Designed Hydrograph for All Cross-Sections during the 50-year Recurrence Flood

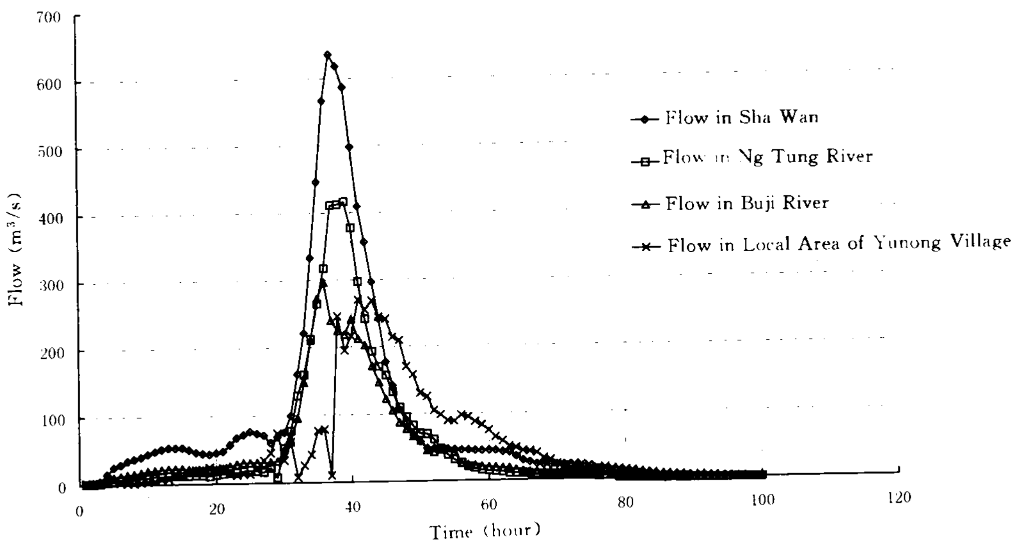

Figure A6. 3 Designed Hydrograph for All Cross-Sections during the 10-year Recurrence Flood

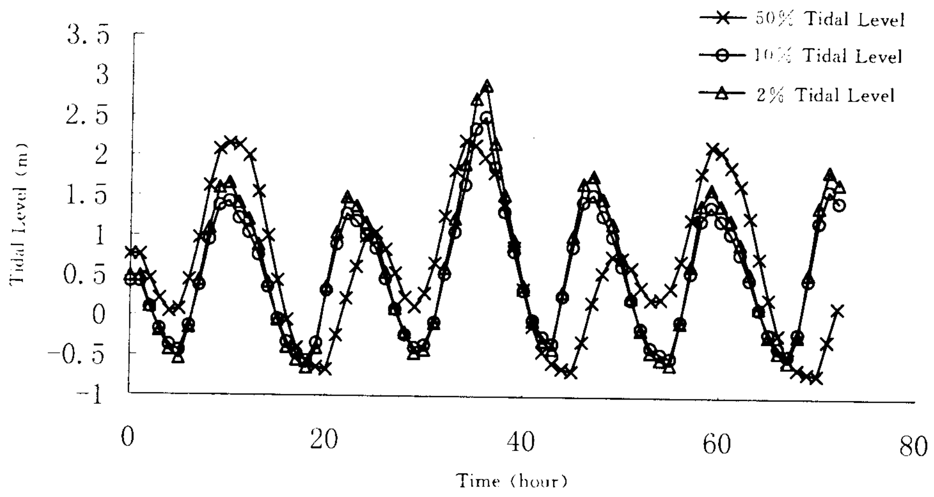

Figure A6.4 Tidal Level Hydrograph in Three Frequencies at the Shenzhen River Estuary

equation. Because the sediment content is not high in the Shenzhen River and the effect of sediment on current is little, this solution method is not only convenient to make model calculation, but also proper to describe the characteristics of sediment transport, scouring and siltation in the Shenzhen River.

A6.4.2 *Model Description*

(1) Essential equation

The St. Venant gradually varied unsteady flow equations, as shown in A6-3, is adopted as the one-dimensional sediment model current equation for the Shenzhen River, and the uniform imbalance sediment transport equation is adopted as the sediment equation. As the riverbed of the Shenzhen River belong to silt bed, besides, there is no data on transport sediment available at present, suspended sediment model is used for the study of sediment.

The current continuous equation:

$$\frac{\partial Z}{\partial t} + \frac{1}{B}\frac{\partial Q}{\partial x} = 0; \qquad (A6-9)$$

The current motion equation:

$$\frac{\partial Q}{\partial t} + \frac{\partial}{\partial x}\left(\frac{Q^2}{A}\right) + gA\frac{\partial Z}{\partial x} + gA\frac{Q|Q|}{K^2} = 0; \qquad (A6-10)$$

The sediment continuous equation:

$$\frac{\partial(A_s)}{\partial t} + \frac{\partial(Q_s)}{\partial x} = -\alpha\omega B(s - s_*); \qquad (A6-11)$$

The sediment carrying capacity of the current:

$$s_* = k\left(\frac{u^3}{gh\omega}\right)^m; \qquad (A6-12)$$

The riverbed deformation equation:

$$\rho' \frac{\partial Z_0}{\partial t} = \alpha\omega(s - s_*); \qquad (A6-13)$$

Here:

Z_0—The average elevation of the riverbed (m)

A_s—The area of the riverbed deformation (m^2)

s —The suspended sediment content (kg/m^3)

s_*—The sand carrying capacity (kg/m^3)

ω — The siltation velocity (m/s)

ρ' —The sediment apparent density (kg/m^3)

α —The sediment recovery saturation coefficient

k, m —The calculating coefficient of the sand carrying capacity

The others are the same as described in Section A6.3.

(2) Calculation scheme

The non-coupling method of current and sediment is applied in solving the above equations. Firstly, the current equation is solved by the method introduced in Section A6.3. Then the sediment continuous equation (A6−11) and the riverbed deformation equation (A6−13), which are discreted with implicit difference scheme, are solved. Refer to Figure A6.5.

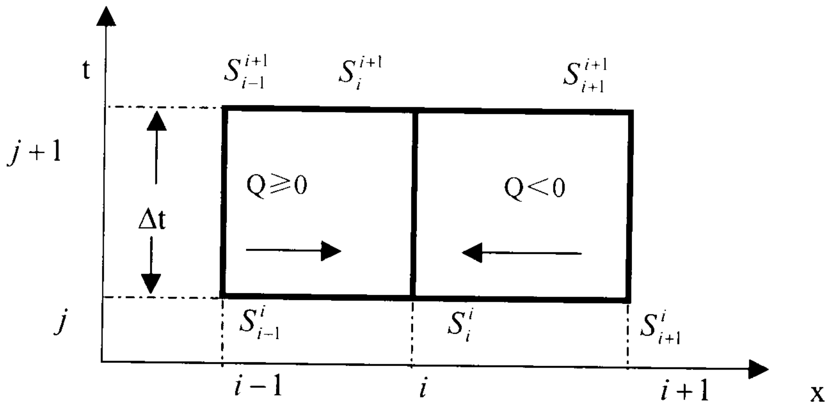

Figure A6. 5 Difference Scheme for Sediment Transport

The sediment continuous equation is discreted as:

$$S_i^{j+1} = \frac{\triangle t\alpha_i^{j+1}B_i^{j+1}\omega_i^{j+1}S_{*i}^{j+1} + A_i^jS_i^j + \dfrac{\triangle t}{\triangle x_{i-1}}Q_{i-1}^{j+1}S_{i-1}^{j+1}}{(A_s)_i^{j+1} + \triangle t\alpha_i^{j+1}B_i^{j+1}\omega_i^{j+1} + \dfrac{\triangle t}{\triangle x_{i-1}}Q_i^{j+1}};(Q\geqslant 0) \qquad (A6-14)$$

$$S_i^{j+1} = \frac{\triangle t\alpha_i^{j+1}B_i^{j+1}\omega_i^{j+1}S_{*i}^{j+1} + A_i^jS_i^j + \dfrac{\triangle t}{\triangle x_i}Q_{i+1}^{j+1}S_{i+1}^{j+1}}{(A_s)_i^{j+1} + \triangle t\alpha_i^{j+1}B_i^{j+1}\omega_i^{j+1} + \dfrac{\triangle t}{\triangle x_i}Q_{i+1}^{j+1}};(Q<0) \qquad (A6-15)$$

The riverbed deformation equation is discreted as:

$$\triangle Z_{0i}^{j+1} = \frac{\triangle t}{\rho^*}\left[\alpha_i^{j+1}\omega_i^{j+1}(S_i^{j+1} - S_{*i}^{j+1})\right]; \qquad (A6-16)$$

A6. 4. 3 Hydrograph of Designed Sediment Loading

The hydrographs of designed sediment loading for withstanding 50-year recurrence and 10-year recurrence flood in the Shenzhen River are got from an empirical formula, which are showed in Figure A6. 6 and Figure A6. 7.

A6. 5 Water Quality Model

A6. 5. 1 Essential Equation

(1) The steady transfer equation of pollutants

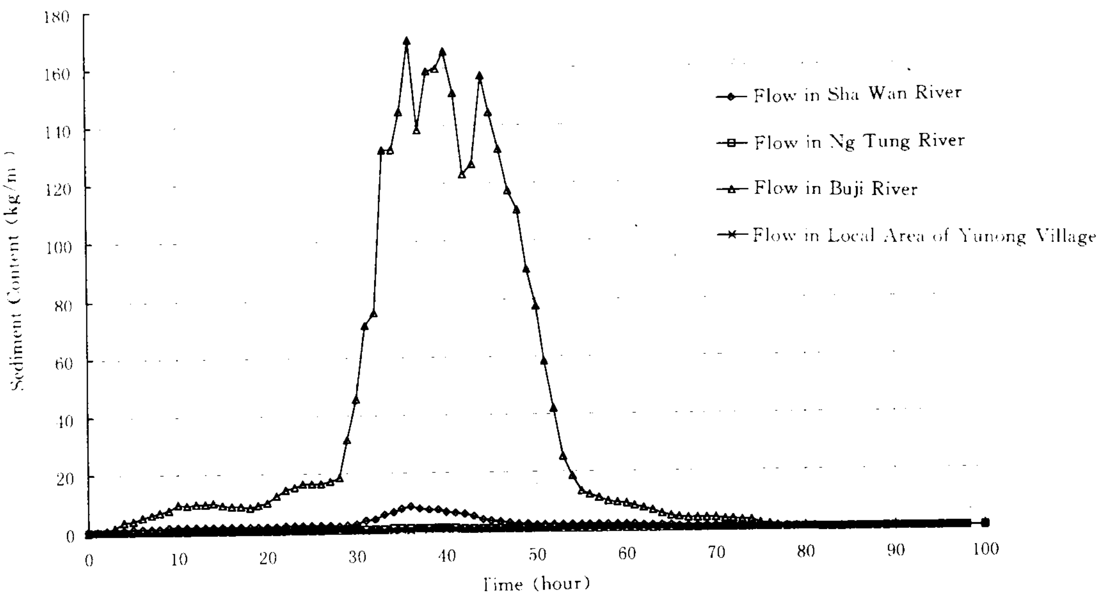

Figure A6. 6 Hydrograph of Designed Sediment Loading for Withstanding 50-year Recurrence Flood

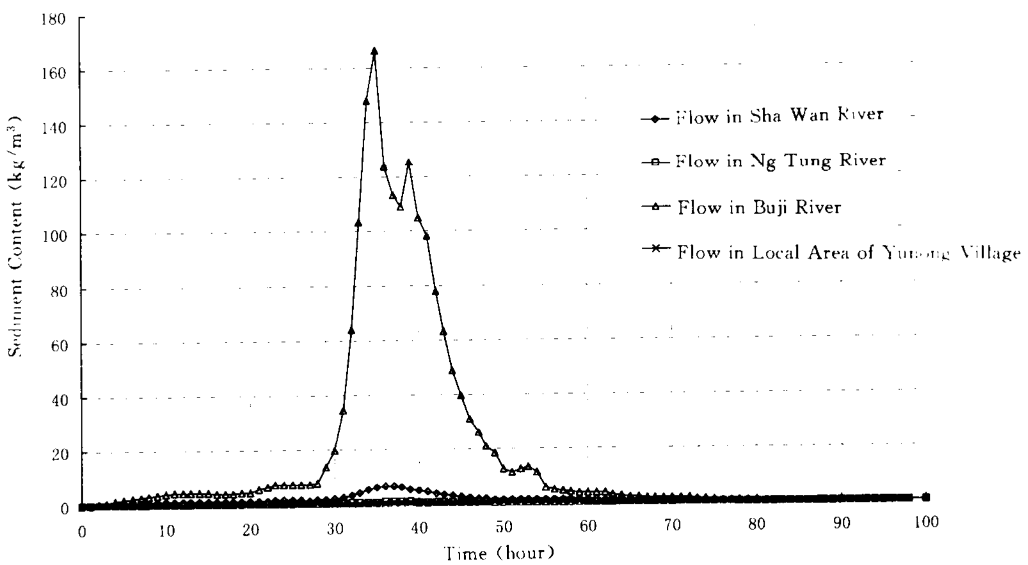

Figure A6. 7 Hydrograph of Designed Sediment Loading for Withstanding 10-year Recurrence Flood

Given the pollutant's average concentration during a tidal cycle, the one-dimensional estuary water quality model for the Shenzhen River can be written out as:

$$\frac{\partial(u_x C)}{\partial x} = \frac{1}{A}\frac{\partial}{\partial x}\left(AD_x\frac{\partial C}{\partial x}\right) + r + s\ ; \qquad (A6-17)$$

Where,

A — The cross-section area for water passage (m^2)

C —The pollutant concentration (mg/L)

x —The distance away from the initial cross-section and towards the direction of stream (m)

u_x—The average current velocity of the river (m/s)

D_x—The longitudinal discrete coefficient (m^2/s)

r, s —The pollutant source and confluction respectively

The basic form of one-dimensional steady transfer equation for description of different pollutants or water quality parameters is the same as the equation (A6—17), only the contents and treatment ways of the sources and confluctions are different.

As to the one-dimensional estuary with stationary cross-sections, with assumption of $s=0$, $r=-KC$, the one-dimensional analytic solution could be got:

For the upstream of the pollution source ($x<0$):

$$\frac{C}{C_0} = exp(J_1 \cdot x)$$

For the downstream of the pollution source ($x<0$):

$$\frac{C}{C_0} = exp(J_2 \cdot x)$$

In which,

$$J_1 = \frac{u_x}{2D_x}\left(1 + \sqrt{1 + {}^{4KD_x}/u_x^2}\right)$$

$$J_2 = \frac{u_x}{2D_x}\left(1 - \sqrt{1 + {}^{4KD_x}/u_x^2}\right)$$

Where C_0 is the pollutant concentration at the place of $x=0$ in the river. It can be calculated by the following formula:

$$C_0 = W/\left[Q\sqrt{1 + \frac{4KD_x}{u_x^2}}\right]$$

Where W is the discharge amount of the pollutant in unit interval, namely intensity of pollution source (g/s);

Q is the average runoff of the river (m^3/s).

The salt concentration in the river can be considered as non-degradable substance without source. At this time, both r and s are zero in the formula A6—4 and the following analytic solution can be got:

$$C = C_0 exp\left(-\frac{u_x x}{D_x}\right) \qquad \text{(A6—18)}$$

Here, $x<0$ when the current is toward the upstream direction. The salinity of the seawater is used as tracer. The value of D_x can be got by the above formula.

Also, the longitudinal discrete coefficient of estuary can apply the following formula:

$$D_x = 63nu_mR^{5/6} \qquad \text{(A6—19)}$$

Where,

R —Hydraulic radius (m)

u_m—The maximum velocity of tide

n —Manning roughness coefficient

(2) BOD_5—DO coupled steady transfer equation

The one-dimensional steady transfer equation, in which DO is indicated as oxygen deficit, is used to describe DO.

$$\frac{\partial(uL)}{\partial x} = \frac{1}{A}\frac{\partial}{\partial x}\left(AD_L\frac{\partial L}{\partial x}\right) + R_L - K_dL \qquad \text{(A6—20)}$$

$$\frac{\partial(uD)}{\partial x} = \frac{1}{A}\frac{\partial}{\partial x}\left(AD_L\frac{\partial D}{\partial x}\right) + R_D - K_a D + K_d L \qquad (A6-21)$$

In the formulas:

L — The concentration of BOD_5(mg/L);

D — The oxygen deficit of O_s-O (mg/L);

O_s— The saturation dissolved oxygen (mg/L);

D_x— The longitudinal discrete coefficient (m^2/s);

K_d— The degradation coefficient (L/d);

K_a— The reaeration coefficient (L/d);

The others are the same as the items ahead.

Supposed the river has stationary cross-section, and if $x=\pm\infty$, then $D=0$, the analytic solution can be work out, too.

A6. 5. 2 *Calculation Scheme*

The finite section model is to longitudinally divide the continuous stream into some volume cells one by one. And supposed that each finite section is a completely mixed zero-dimensional model, the whole stream section can be simulated approximately with a discrete one-dimensional model. In the finite section model, the averages during the tidal cycle are taken for the stream and the water quality parameters, and the computed flow in the model is the average net flow of the stream.

(1) BOD model

During a tidal cycle, the mass balance relationship of the pollutant in cell i of any finite section is described as follows:

The varied rate of water quality = runoff shift action + discrete action + degradation action + source (the discharge amount) (A6—22)

As to BOD, the relationship will be:

The varied rate of water quality $= \frac{d(V_i L_i)}{dt}$

Where,

V_i— The volume of section i (m^3);

L_i— The concentration of BOD in section i (mg/L).

The mass variation caused by runoff shift action $= Q_{i-1,i}L_{i-1,i} - Q_{i,i+1}L_{i,i+1}$

Where Q is the average net flow during a tidal cycle. The subscript j and k indicate the value between section j and section k. The BOD concentration at the interface of the two sections can be expressed as the following formula:

$$L_{i-1,i} = \alpha_{i-1,i}L_{i-1} + (1 - \alpha_{i-1,i})\, L_i$$

Where α is weight factor, it is

$$\alpha_{i-1,i} = \frac{\triangle x_{i-1}}{\triangle x_{i-1} + \triangle x_i}$$

Where $\triangle x_{i-1}$ and $\triangle x_i$ are the length of two consecutive sections, namely section i—1 and section i respectively.

The mass variation caused by discrete action $= (L_{i-1} - L_i)\dfrac{D_{i-1,i}A_{i-1,i}}{\triangle x_{i-1,i}} + (L_i - L_{i+1})\dfrac{D_{i,i+1}A_{i,i+1}}{\triangle x_{i,i+1}}$

Here:

$$\triangle x_{i,j} = \frac{1}{2}(\triangle x_i + \triangle x_j)$$

$D_{i,j}$— The discrete coefficient at the interface of section i and section j;

$A_{i,j}$— The cross-section area at the interface of section i and section j;

$\triangle x_{i,j}$— The discrete coefficient of the center distance between section i and section j.

The mass variation caused by discrete action $= - V_i K_{di} L_i$

Here,

K_{dj}— The degradation coefficient of BOD in section i.

The pollutant source $= W_{1i}$,

Where W_{1i} is the BOD amount discharged into section i in unit interval.

And now, based on the relationship of mass conservation, the balance equation of BOD can be expressed as

$$\frac{d(V_iL_i)}{dt} = Q_{i-1,i}[\alpha_{i-1,i}L_{i-1} - (1-\alpha_{i-1,i})L_i] - Q_{i,i+1}[\alpha_{i,i+1}L_i - (1-\alpha_{1,i+1})L_{i+1}]$$
$$+ D_{i-1,i}(L_{i-1} - L_i) + D_{i-1,i}(L_{i+1} - L_i) - V_iK_{1i}L_i + W_{1i} \qquad \text{(A6-23)}$$

Here,

$$D'_{i,j} = D_{i,j}A_{i,j}/\triangle x_{i,j}$$

The following BOD steady model for estuary can be got if $\frac{d(V_iL_i)}{dt} = 0$ in the equation A6-7.

$$G\vec{L} = \vec{W}_1 \qquad \text{(A6-24)}$$

Here,

$\vec{L}$ —The n-dimensional vector that consists of BOD concentration values of all reaches;

$\vec{W}_1$ —The n-dimensional vector that consists of the BOD amounts discharged from all reaches.

G — A nth order matrix. All elements in the matrix can be got from the following relation:

$$g_{i,i-1} = - Q_{i,i-1}\alpha_{i,i-1} - D_{i-1,j}$$

$$g_{i,i} = Q_{i,i+1}\alpha_{i,i+1} - Q_{i-1,i}(1 - \alpha_{i-1,i}) + D_{i,i+1} + D_{i,i+1} + V_iK_{di}$$

$$g_{i,i+1} = Q_{i,i+1}(1 - \alpha_{i,i+1}) - D_{i,i+1}$$

For the other elements, $g_{i,j} = 0$。

(2) Dissolved oxygen model

Based on the formula A6-6, the balance relation of oxygen content can be got with the expression of oxygen deficit:

$$\frac{d(V_iD_i)}{dt} = Q_{i-1,i}[\alpha_{i-1,i}D_{i-1} - (1-\alpha_{i-1,i})D_i] - Q_{i,i+1}[\alpha_{i,i+1}D_i - (1-\alpha_{i,i+1})D_{i+1}]$$
$$+ D_{i-1,i}(D_{i-1} - D_i) + D_{i-1,i}(D_{i+1} - D_i) - V_iK_{di}L_i + V_iK_{ai}D_i + W_{2i} \quad \text{(A6-25)}$$

Here,

K_{aj} — The reaeration coefficient of section i;

W_{2i} — The oxygen deficit amount discharged into section i in unit interval.

If let $\frac{d(V_iD_i)}{dt} = 0$, the steady model of dissolved oxygen for estuary can be got. The equation of this model can described as the following matrix:

$$H\vec{D} = F\vec{L} + \vec{W}_2 \quad \text{(A6-26)}$$

Here,

$\vec{D}$ — The n-dimensional vector that consists of the oxygen deficit values of all reaches.

$\vec{W}_2$ — The n-dimensional vector that consists of oxygen deficit amounts discharged into all reaches in unit interval.

Both of H and F are nth-order matrixes. All elements of the matrixes can be got from the following relation.

For H:

$$h_{i,i-1} = -Q_{i,i-1}\alpha_{i,i-1} - D_{i-1,i}$$

$$h_{i,i} = Q_{i,i+1}\alpha_{i,i+1} - Q_{i-1,i}(1-\alpha_{i-1,i}) + D_{i-1,i} + D_{i,i+1} + V_iK_{ai}$$

$$h_{i,i+1} = Q_{i,i+1}(1-\alpha_{i,i+1}) - D_{i,i+1}$$

For the other elements: $h_{i,j} = 0$

For F:

$$f_{i,i} = V_iK_{di}$$

For the other elements: $f_{i,j} = 0$。

The equation A6—24 and equation A6—26 just are estuary one-dimension steady coupling models of BOD-DO for trans-tide weekly average. It is a popular model used in estuary water quality simulating and planning, which has good result.

The following equations can be got from the equation A6—24 and A6—26.

$$\left.\begin{aligned} \vec{L} &= G^{-1}\vec{W}_1 \\ \vec{D} &= H^{-1}FG^{-1}\vec{W}_1 + H^{-1}\vec{W}_2 \end{aligned}\right\} \qquad (A6-27)$$

The inverse matrix G^{-1} is named as steady transfer matrix, which expresses the responsive BOD values in all other reaches upon input of BOD in a reach. Similarly, $H^{-1}FG^{-1}$ expresses the responsive DO value in all other reaches upon input of BOD, and H^{-1} expresses the responsive oxygen deficit value at estuary upon the oxygen deficit input.

(3) Boundary condition

Input the upper and the lower boundary values (including L_0、L_{n+1}、D_0、D_{n+1}) of pollutant concentration into equation A6—24 and A6—26, and reckon the items (all are already known) where they are in the input sources, besides, vectors $\vec{W}_1$ and $\vec{W}_2$ must be modified as follows:

$W_{1,1}$ *as* $W_{1,1} + (Q_{0,1}\alpha_{0,1} + D_{0,1})L_0$

$W_{1,n}$ *as* $W_{1,n} + [-Q_{n,n+1}(1 - \alpha_{n,n+1}) + D_{n,n+1}]L_{n+1}$

$W_{2,1}$ *as* $W_{2,1} + (Q_{0,1}\alpha_{0,1} + D_{0,1})D_0$

$W_{1,1}$ *as* $W_{2,n} + [-Q_{n,n+1}(1 - \alpha_{n,n+1}) + D_{n,n+1}]D_{n+1}$

The methods for the discrete and solution of the other single-factor pollutants are the same as that of BOD.

A6.5.3 *Essential information*

The statistic data inputted into the model before and after the Project are showed in Table A6.5 and Table A6.6.

Table A6. 5 **Statistic Data as Inputs into the Model for before the Project**

Cross-Section	Section Number	Section Length (m)	Section Width (m)	Section Depth (m)	Inputted Discharge (m^3/s)	COD_{Mn} (mg/l)	BOD_5 (mg/l)	TN (mg/l)	TP (mg/l)	Total Coliform (10^4cell/l)	TCu (mg/l)	TPb (mg/l)	Flow of cross-section (m^3/s)	Water Temperature (℃)	DO (mg/l)
Mouth of River Gange						12.84	14.91	14.25	2.098	65400	0.0303	0.01	2.71	29.4	
San Pan River	1#	1100	16.3	0.73	0.64	52.5	33.04	15.44	1.481	6000	0.0042	0.0023	3.35	29.9	0.2
Lo Wu Bridge	2#	3945	26.9	0.98	2.12	23	12	3.31	0.61	1000	0.057	0.012		29	0.2
Yumin Village	3#	828	41.34	1.35	9.87	22.87	47.34	14.87	1.901	190	0.0288	0.0062		28.8	0.2
Buji River Mouth	4#	1883	48.16	1.65	0.69	13.19	12.84	11.79	2.06	3200	0.013	0.004	17.02	29.2	0.2
Futian River Mouth	5#	2953	54.5	1.76	3.68	21.96	33.53	12.19	1.818	7900	0.041	0.018		29.5	0.2
Yunong Village	6#	3290	66.07	1.89	2.21	23.32	28.24	9.04	2.358	16000	0.024	0.072	24.39	29.7	0.2
Shenzhen River Estuary	7#	3219	79.51	2.02	1.27	47.63	66.8	28.06	4.01	91000	0.044	0.003	31.05	29.5	0.2

Table A6. 6 **Statistic Data as Inputs into the Model for after the Project**

Cross-Section	Section Number	Section Length (m)	River Width (m)	Water Depth (m)	Inputted Discharge (m^3/s)	COD_{Mn} (mg/l)	BOD_5 (mg/l)	TN (mg/l)	TP (mg/l)	Total Coliform (10^4cell/l)	TCu (mg/l)	TPb (mg/l)	Flow of Cross-section (m^3/s)	Water Temperature (C)	DO (mg/l)
Mouth of River						12. 84	14. 91	14. 25	2. 098	65400	0. 0303	0. 01	2. 71	29. 4	
San Pan River	1#	994	55. 2	3. 31	0. 64	52. 5	33. 04	15. 44	1. 481	6000	0. 0042	0. 0023	3. 35	29. 9	0. 2
Lo Wu Bridge	2#	3945	43. 9	4. 64	2. 12	23	12	3. 31	0. 61	1000	0. 057	0. 012		29	0. 2
Yumin Village	3#	200	51. 15	4. 66	9. 87	22. 87	47. 34	14. 87	1. 901	190	0. 0288	0. 0062		28. 8	0. 2
Buji River Mouth	4#	1030	66. 16	4. 71	0. 69	13. 19	12. 84	11. 79	2. 06	3200	0. 013	0. 004	17. 02	29. 2	0. 2
Futian River Mouth	5#	2958	97. 5	4. 86	3. 68	21. 96	33. 53	12. 19	1. 818	7900	0. 041	0. 018		29. 5	0. 2
Yunong Village	6#	1120	102. 7	5. 02	2. 21	23. 32	28. 24	9. 04	2. 358	16000	0. 024	0. 072	24. 39	29. 7	0. 2
Shenzhen River Eatuary	7#	3219	120. 1	5. 16	1. 27	47. 63	66. 8	28. 06	4. 01	91000	0. 044	0. 003	31. 05	29. 5	0. 2

A6. 5. 4 *Figure*

Figure A6. 8—Figure A6. 38 are sketch profiles of model parameter calibration, model verification, and prediction.

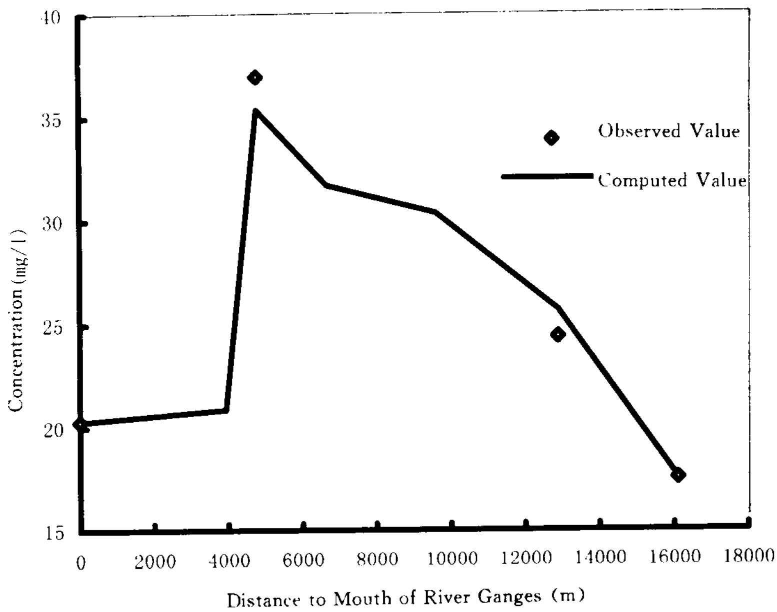

Figure A6. 8 Parameter Estimate of BOD Model

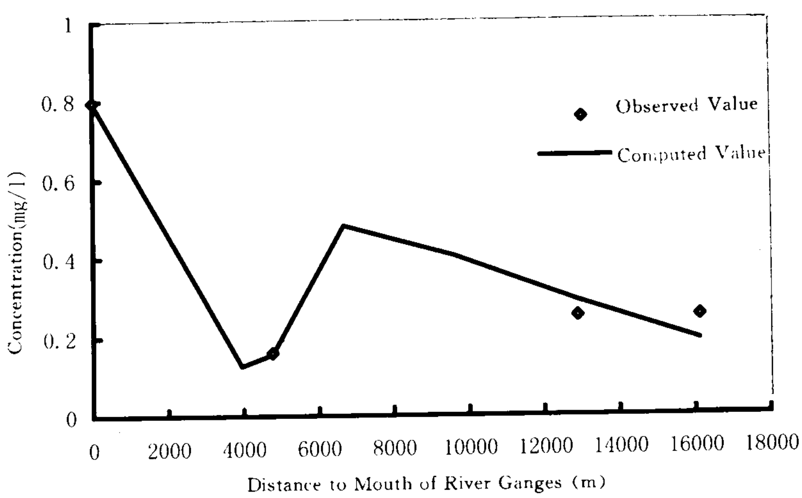

Figure A6. 9 Parameter Estimate of DO Model

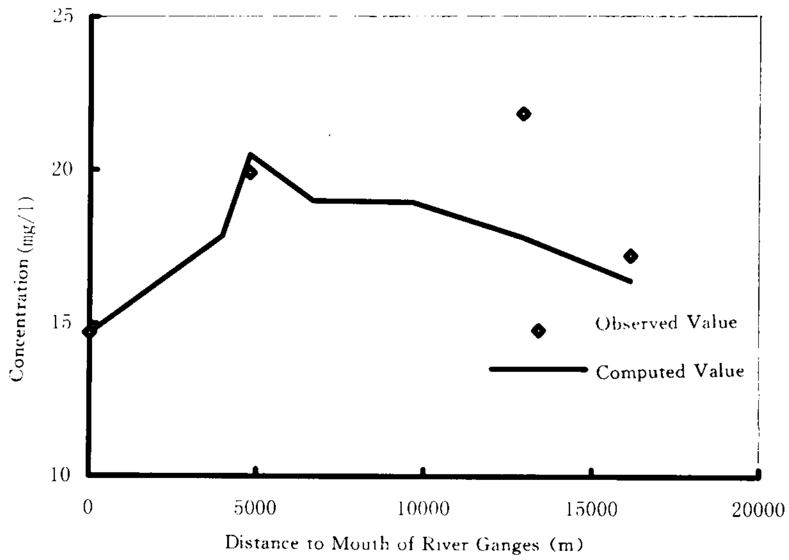

Figure A6. 10 Parameter Estimate of COD Model

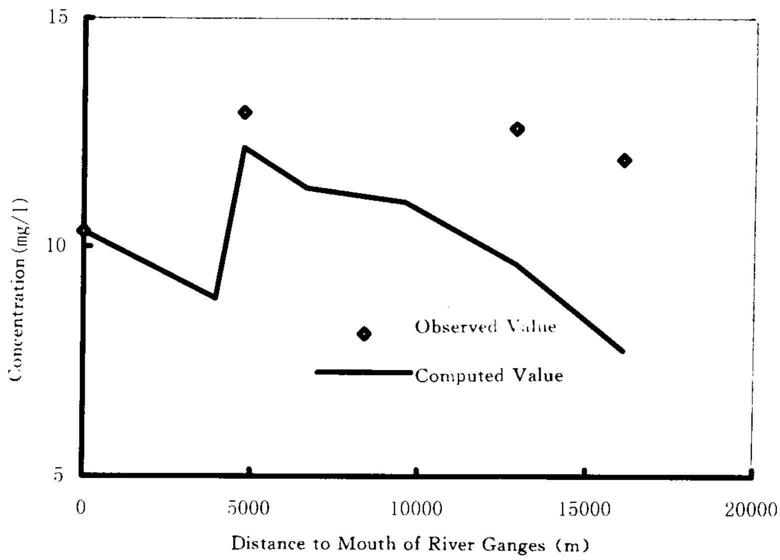

Figure A6. 11 Parameter Estimate of TN Model

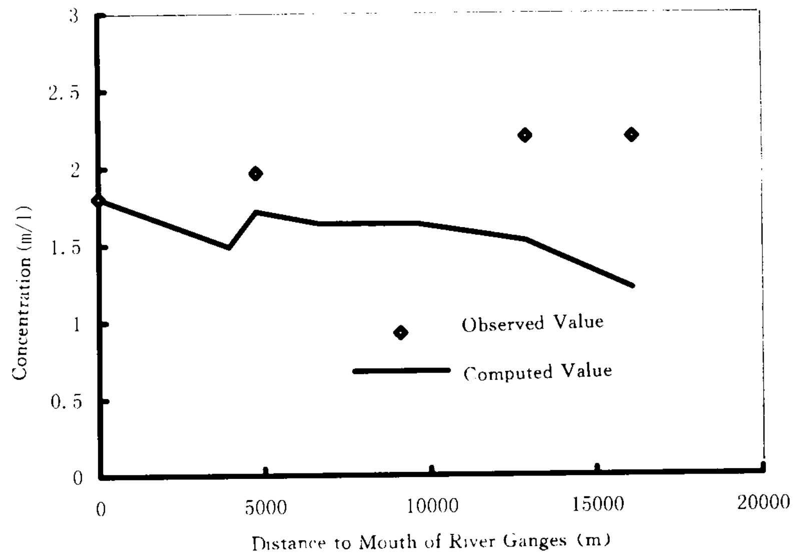

Figure A6. 12 Parameter Estimate of TP Model

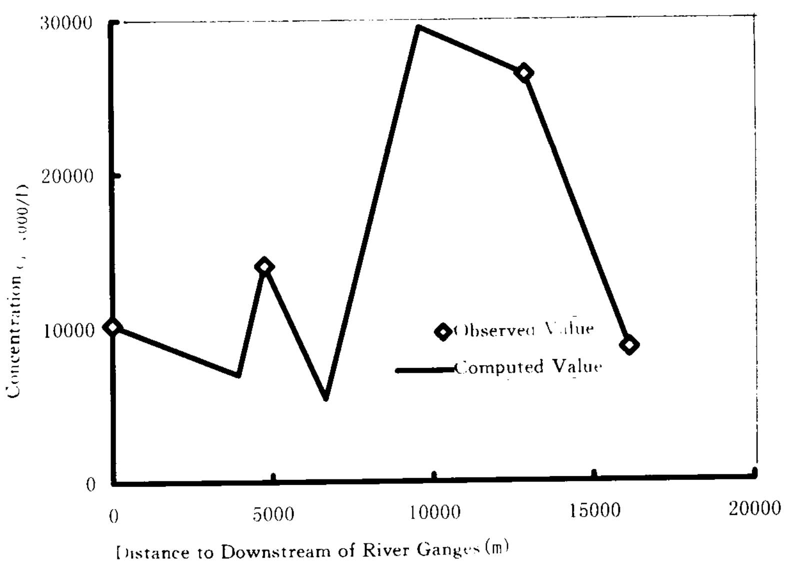

Figure A6. 13 Parameter Estimate of Total Coliform Model

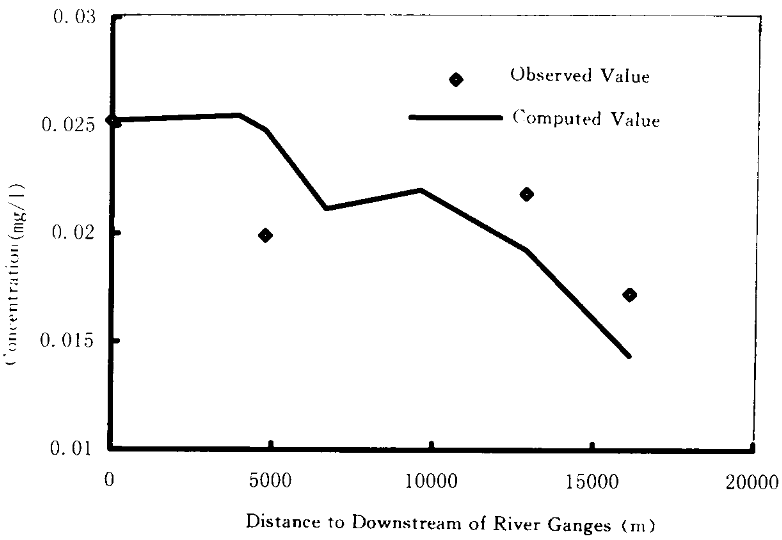

Figure A6. 14 Parameter Estimate of Total Cu Model

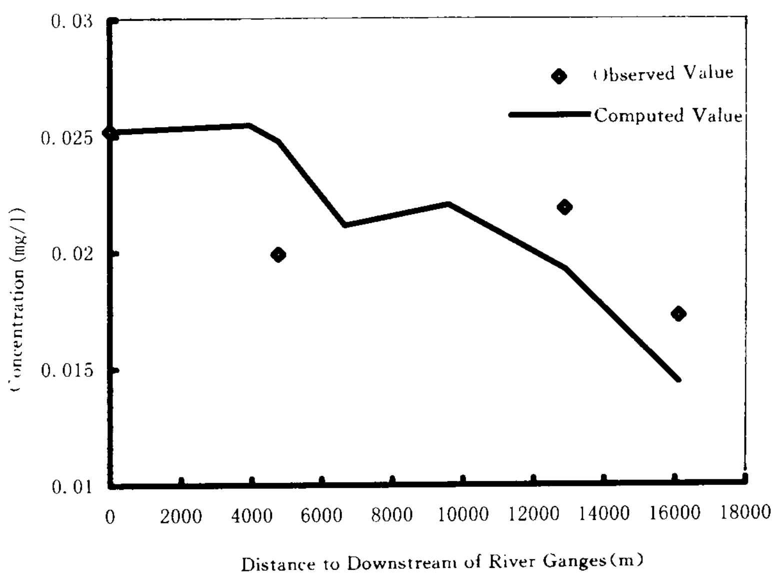

Figure A6. 15 Parameter Estimate of Total Pb Model

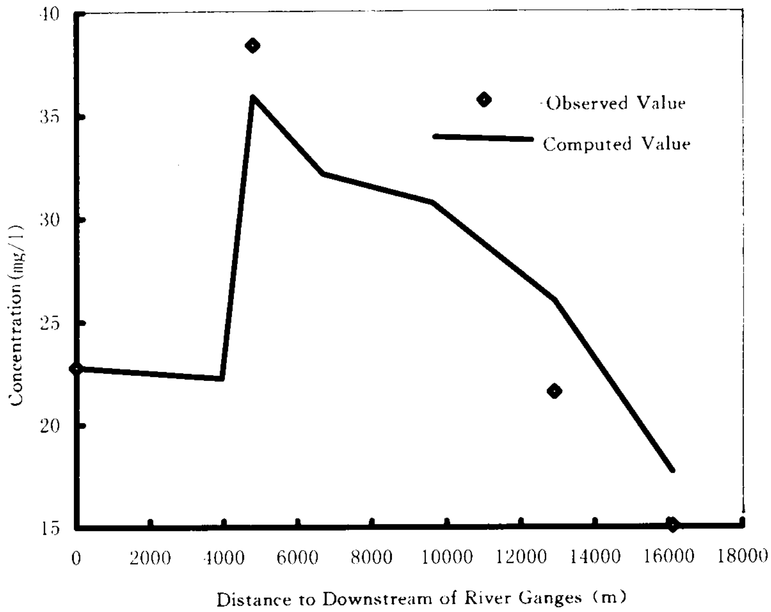

Figure A6. 16 BOD Model Verification

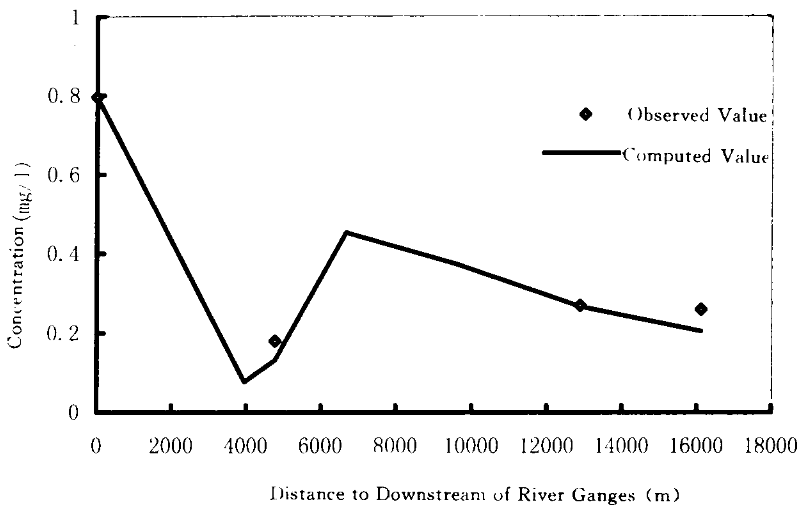

Figure A6. 17 DO Model Verification

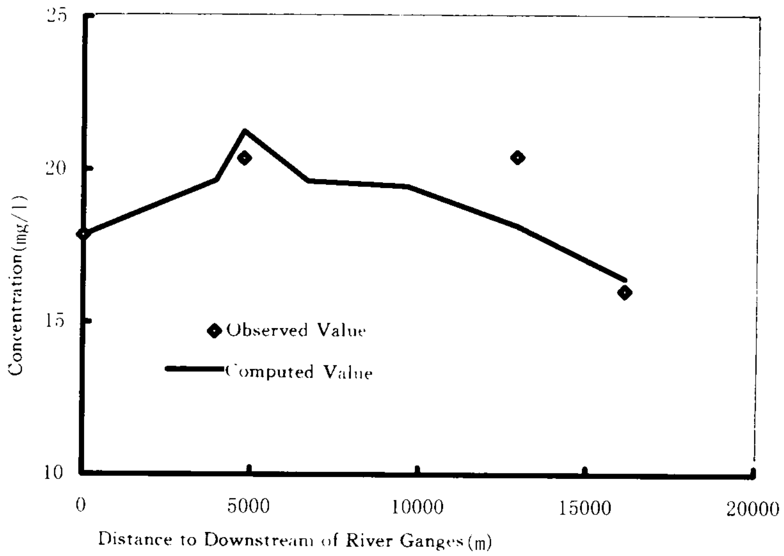

Figure A6. 18 COD Model Verification

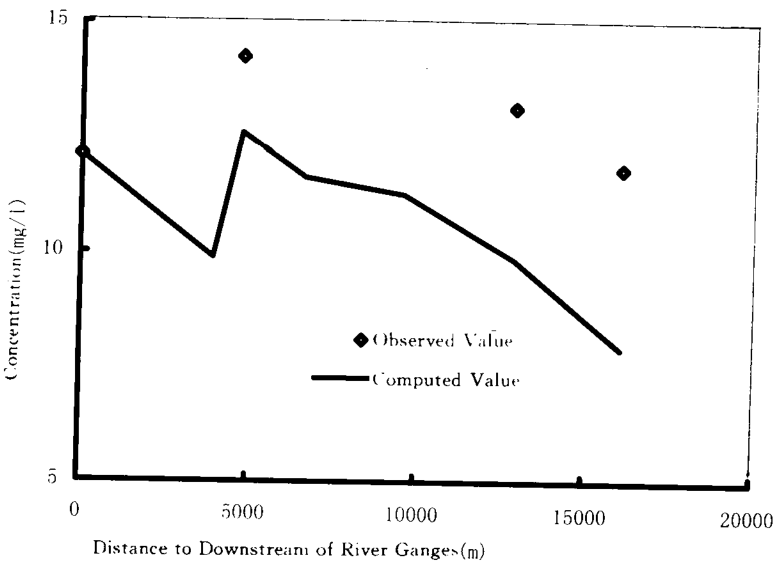

Figure A6. 19 TN Model Verification

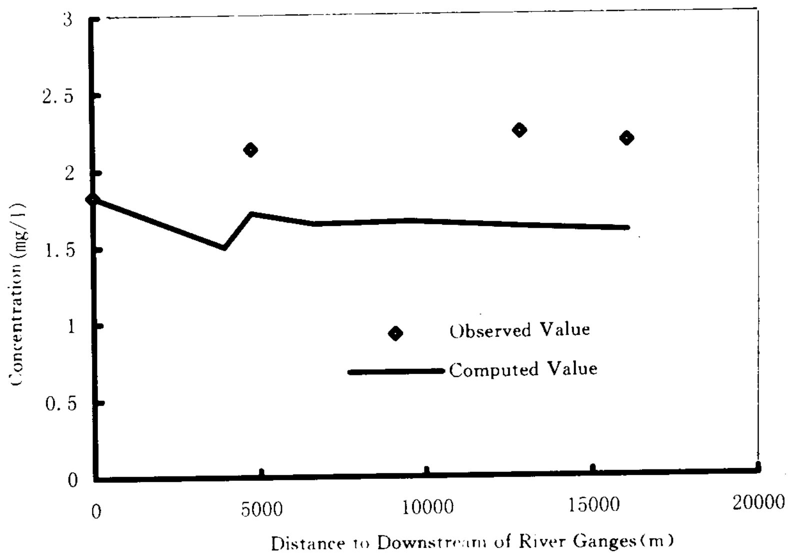

Figure A6. 20 TP Model Verification

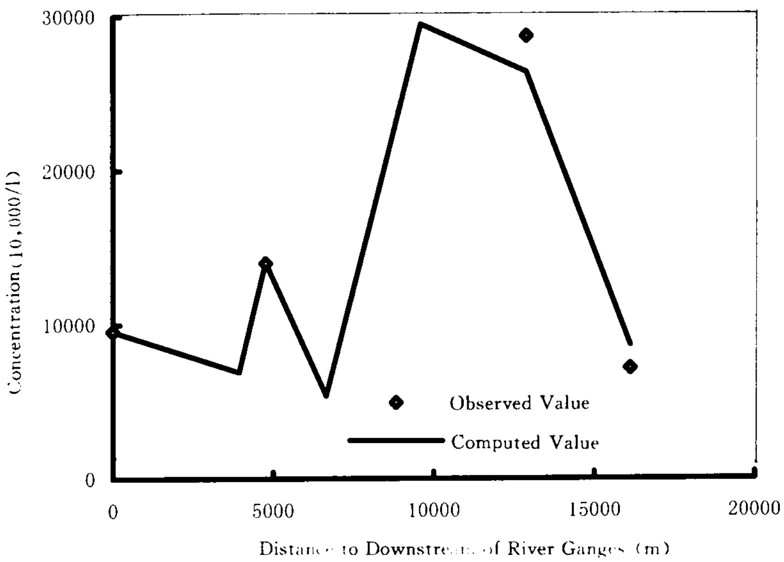

Figure A6. 21 Total Coliform Model Verification

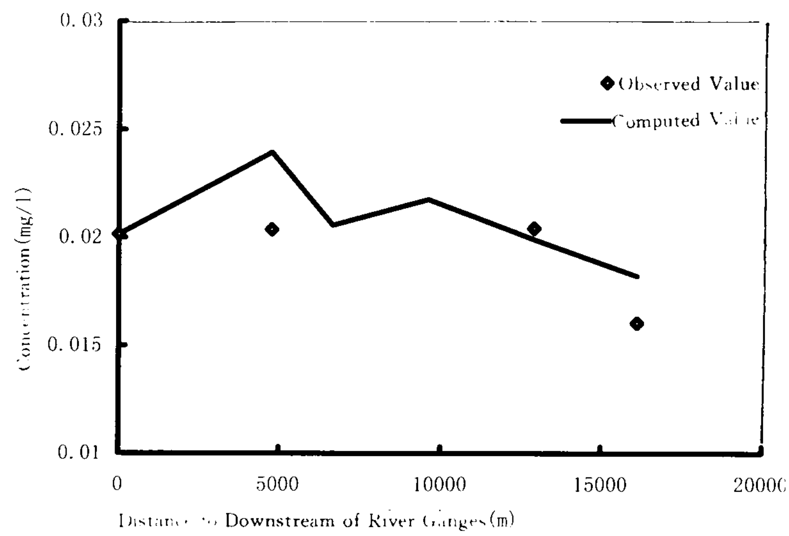

Figure A6. 22 Total Cu Model Verification

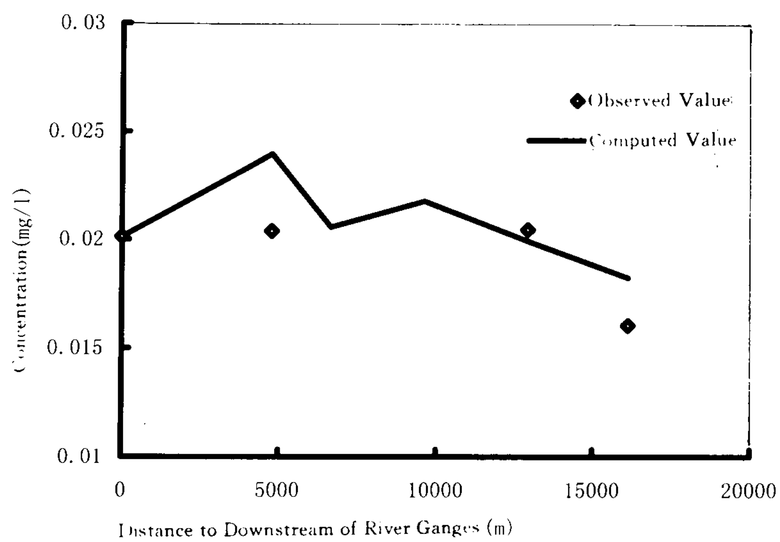

Figure A6. 23 Total Pb Model Verification

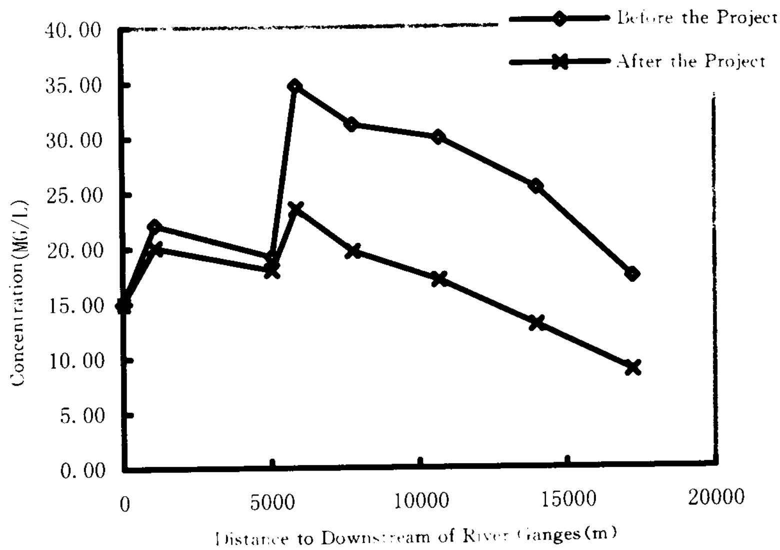

Figure A6. 24 BOD Simulating before and after the Project

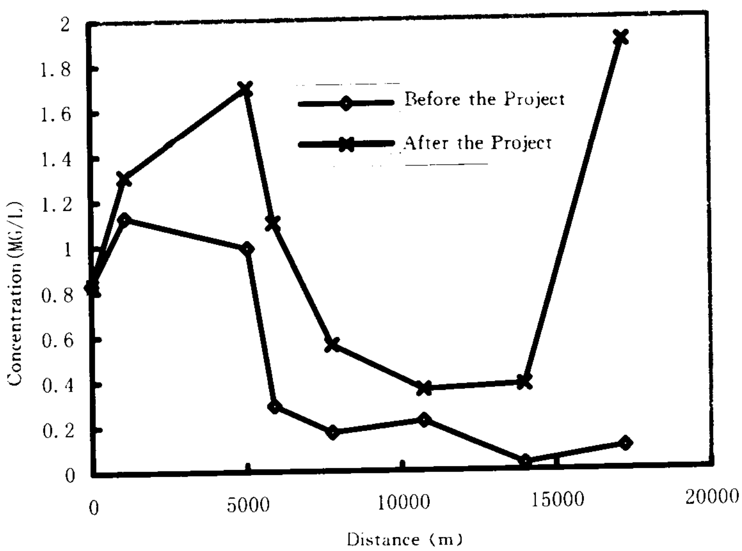

Figure A6. 25 DO Simulating before and after the Project

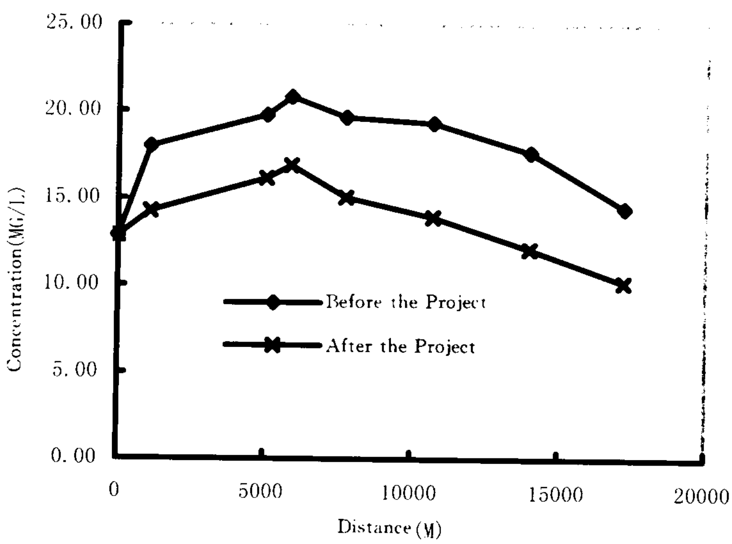

Figure A6. 26 COD Simulating before and after the Project

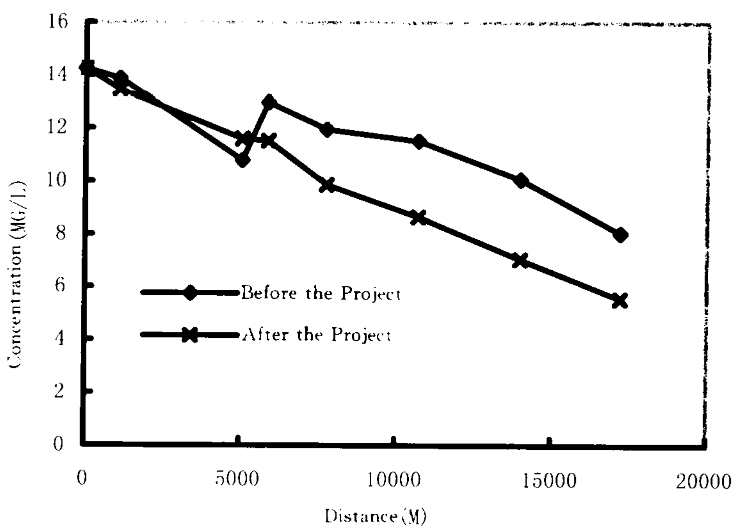

Figure A6. 27 TN Simulating before and after the Project

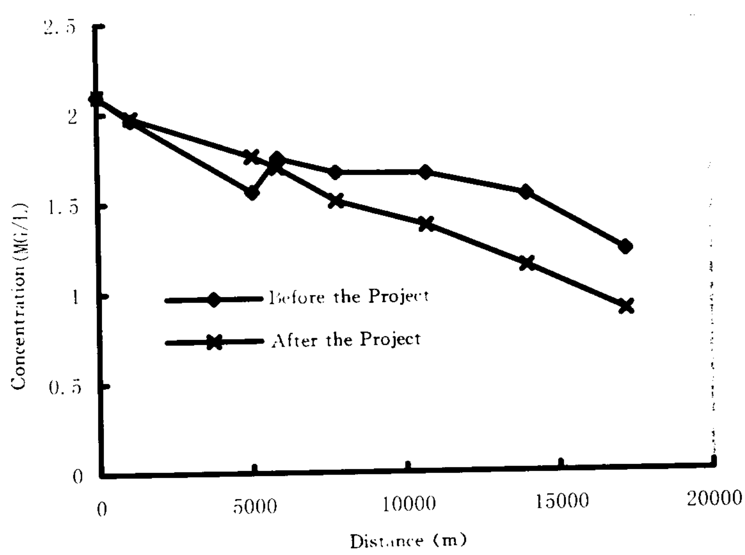

Figure A6. 28 TP Simulating before and after the Project

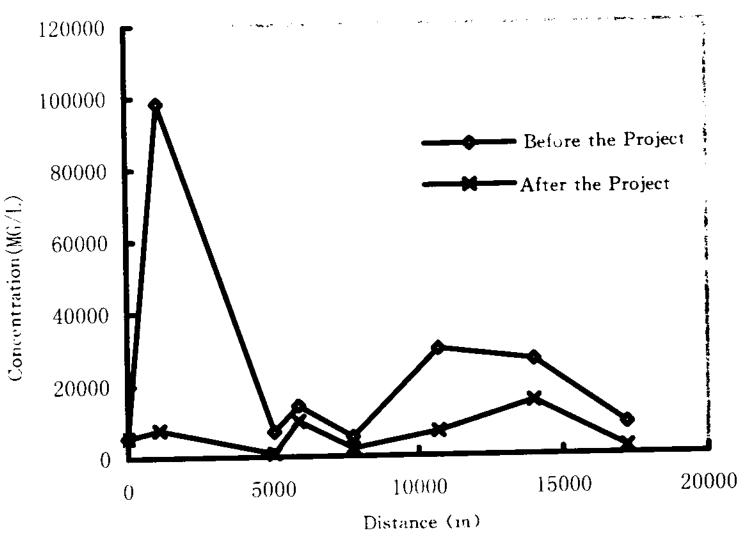

Figure A6. 29 Total Coliform Simulating before and after the Project

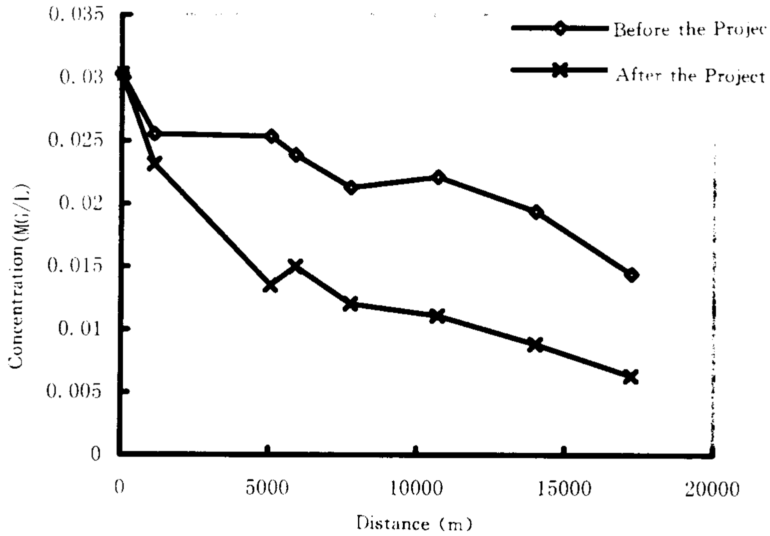

Figure A6. 30 Total Cu Simulating before and after the Project

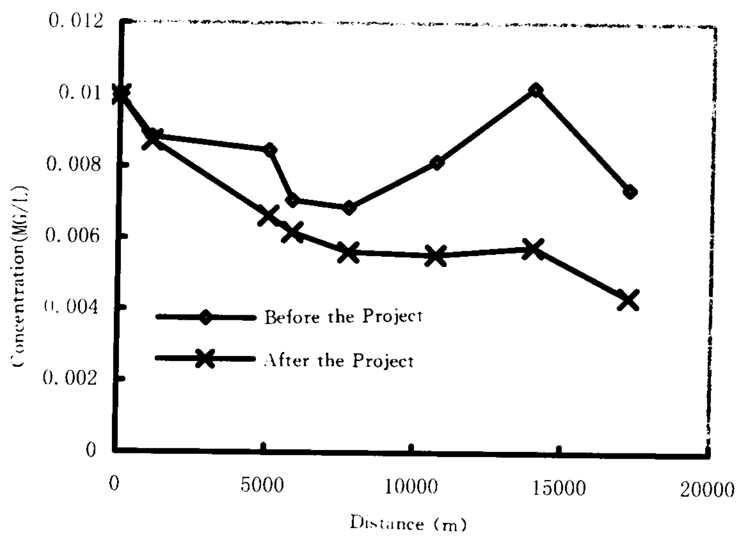

Figure A6. 31 Total Pb Simulating before and after the Project

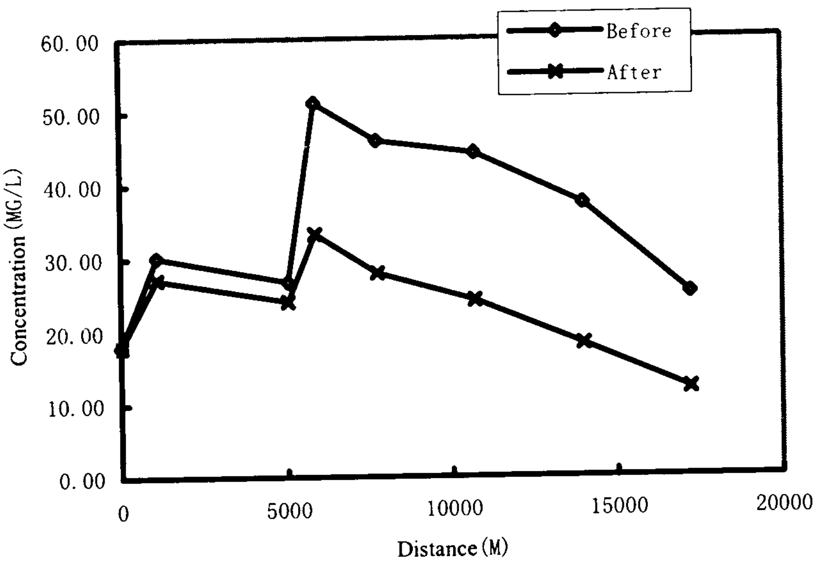

Figure A6. 32 BOD Simulating in Planning Year before and after the Project

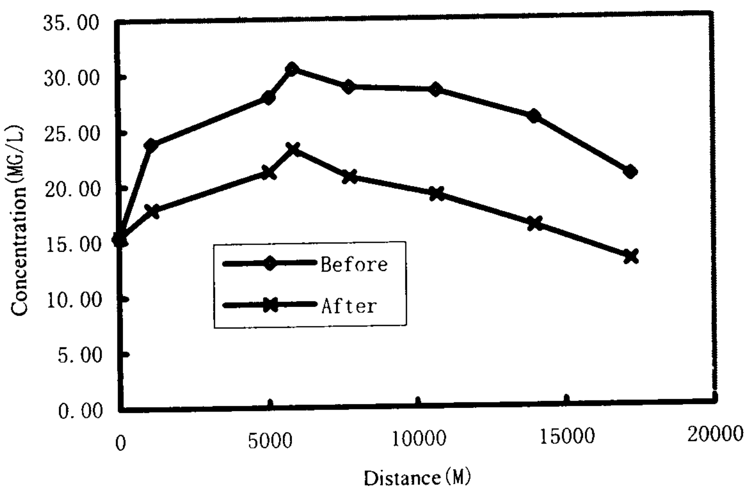

Figure A6. 33 COD Simulating in Planning Year before and after the Project

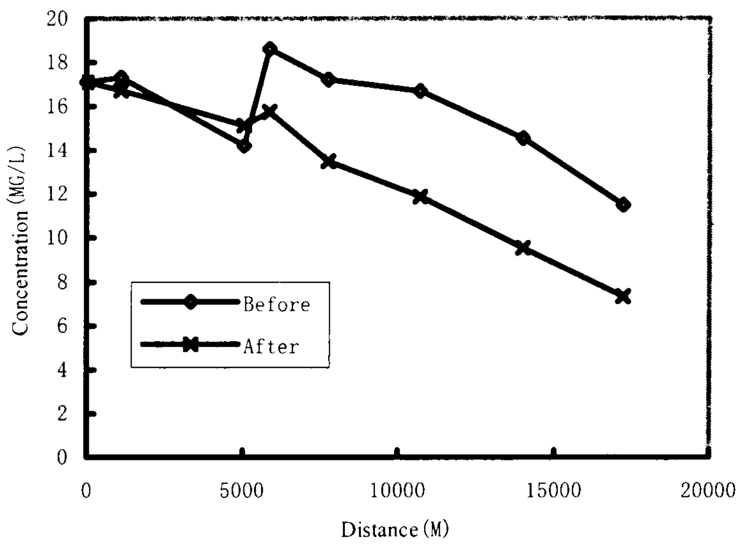

Figure A6. 34 TN Simulating in Planning Year before and after the Project

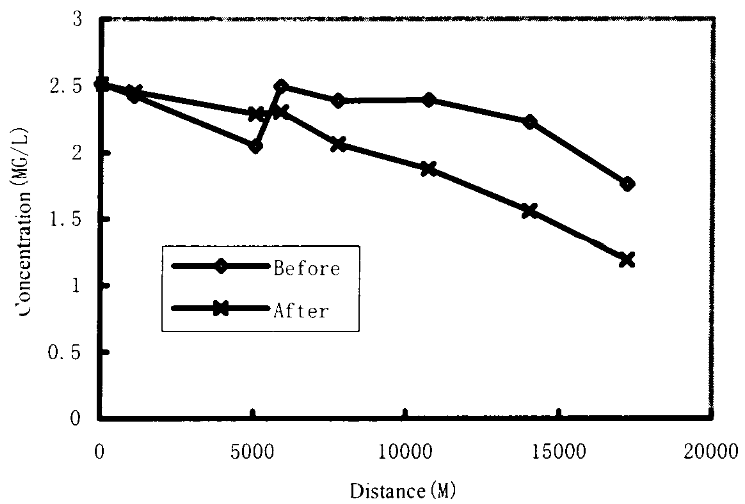

Figure A6. 35 TP Simulating in Planning Year before and after the Project

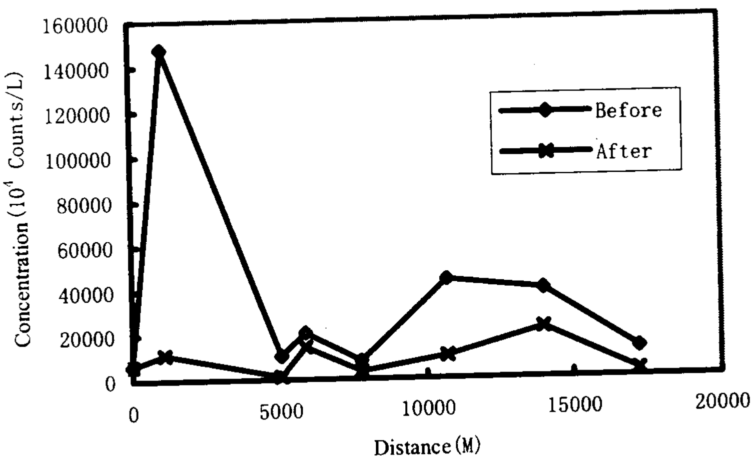

Figure A6.36 COLI Simulating in Planning Year before and after the Project

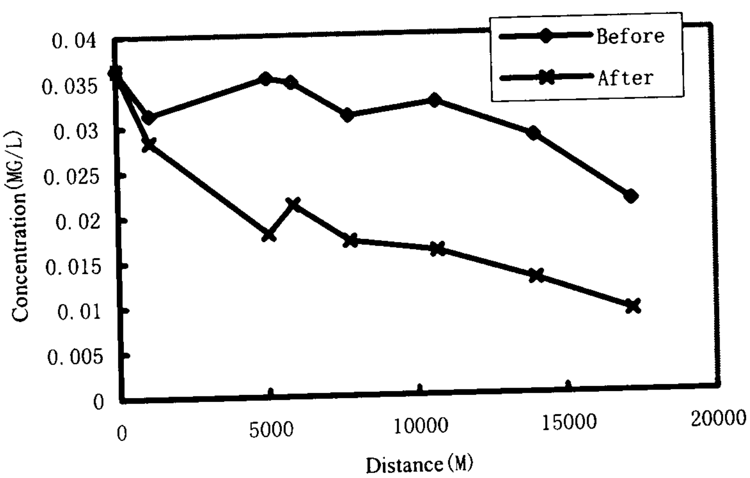

Figure A6.37 TCu Simulating in Planning Year before and after the Project

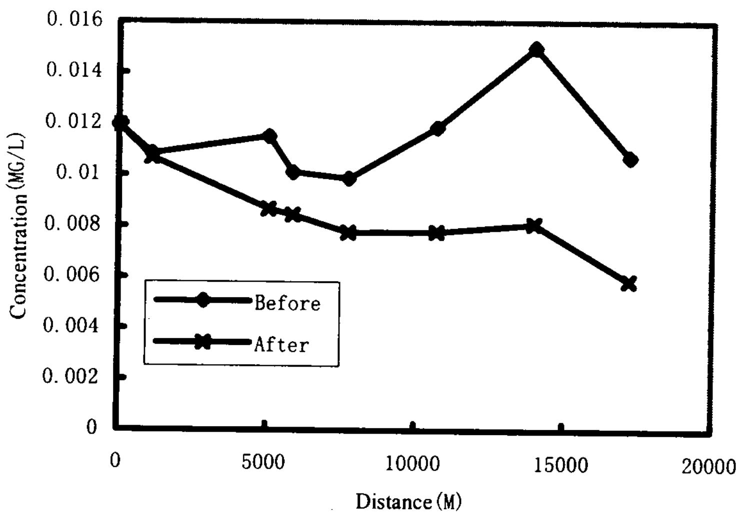

Figure A6.38 TPb Simulating in Planning Year before and after the Project